HWCI 2.2.2
Ballast Subsystem

- Requirements Traceability
  - 2.1.2, 2.2.1.1, 2.2.1.3
- Functional and Performance Requirements
  - 2.2.2.a: Provide a repository for ballast material
  - 2.2.2.b: Provide a method for releasing ballast at a controlled rate upon command
  - 2.2.2.c: Maintain functionality and structural integrity in ULDB environment for mission duration
- HWCI Description
  - Use standard LDB ballast hopper and valves
  - Weight: 7 lb total

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HWCI 2.2.2
Ballast Subsystem

- Risk Assessment & Mitigation/Reliability
  - Proven design
  - Risk: Valve failure
    - Redundant valves
  - Risk: Hopper structural failure
    - Multiple attachment points
- Verification

Req. No.	Requirement	Verification Method
2.2.2.a	Ballast Storage	Calculation
		Demonstration
		Test Flight(s)
2.2.2.b	Ballast Release	Thermal Analysis
		Thermal Vacuum Functional Test
		Test Flight(s)
2.2.2.c	Structural Integrity	Material UV Exposure Analysis
		Material UV Exposure Test
		Test Flight(s)

HWCI 2.3.1
Parachute System

- Requirements Traceability
  - 2.3, 2.4.1
- Functional and Performance Requirements
  - 2.3.1.a: Provide safe, controlled payload descent from termination altitude to ground impact
  - 2.3.1.b: Maintain functionality and structural integrity in ULDB environment for mission duration

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HWCI 2.3.1
Parachute System

- Trade Studies

	Performance	Mat'l Concerns	Size	Power	Interfaces	Cost	Risk	Schedule	Weight	Score
weight	1.5	2	1	1	1	1.5	2	2	1.5	
Enveloped Flat Circular	7	10	4	10	9	7	8	8	8	108
Flat Circular, As Is	7	3	5	10	10	9	9	10	9	106.5
Packed Flat Circular	7	8	8	9	8	7	7	7	8	102
Packed 2-Stage System	9	8	7	9	8	5	6	6	8	97
GPS-Guided Parafoil	10	8	3	7	5	3	3	3	4	68.5

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HWCI 2.3.1
Parachute System

- HWCI Description
  - Parachute shall be 120-foot-diameter flat circular design commonly used on conventional balloons
  - Parachute will be enshrouded in a 6-ft-dia. protective sleeve of 1-mil opaque polyethylene material to lower UV exposure of parachute materials
  - Sleeve will be suspended from a spreader ring attached to the upper termination fitting
  - Sleeve will be of sufficient length to conceal parachute canopy and suspension lines
  - Weight: 494 lb

HWCI 2.3.1
Parachute System

- Risk Assessment & Mitigation/Reliability
  - Proven parachute design
  - New sleeve design
  - Risk: Structural failure or improper inflation of parachute
    - No mitigation

- Verification

Req. No.	Requirement	Verification Method
2.3.1.a	Controlled Descent	Descent Analysis
		Inspection
		Subscale Sleeve Tests
		Test Flight(s)
2.3.1.b	Structural Integrity	Material Exposure Analysis
		Pull Test
		Test Flight(s)

HWCI 2.3.2
Land Impact Attenuator

- Requirements Traceability
  - 2.3
- Functional and Performance Requirements
  - 2.3.2.a: Minimize land impact damage
  - 2.3.2.b: Maintain functionality and structural integrity in ULDB environment for mission duration
- Trade Studies

	Performance	*Weight*	*Size*	*Cost*	*Schedule*	*Power*	*Interfaces*	*Risk*	Score
weight	2	2	1	2	2	1	1	2	
Aluminum Honeycomb	5	5	5	4	5	5	5	5	63
Paper Honeycomb	4.5	5	4	5	5	5	5	5	63
Air Bags	4	3	5	3	3	4	3	3	44

HWCI 2.3.2
Land Impact Attenuator

- HWCI Description
  - Four each 1-cubic-foot aluminum honeycomb cubes affixed to gondola legs
  - Weight: 4 lb total
- Risk Assessment & Mitigation/Reliability
  - Standard sounding rocket impact attenuator
  - Risk: Insufficient attenuation
    - No mitigation
- Verification

Req. No.	Requirement	Verification Method
2.3.2.a	Impact Attenuation	Strength Analysis
		Drop Test(s)
		Test Flight(s)
2.3.2.b	Structural Integrity	Material Exposure Analysis
		Test Flight(s)

HWCI 2.4.1
Terminate Fitting

- Requirements Traceability
  - 2.4.2, 3.9.2
- Functional and Performance Requirements
  - 2.4.1.a: Provide separation of payload from balloon upon command
  - 2.4.1.b: Maintain functionality and structural integrity in ULDB environment for mission duration
- HWCI Description
  - Use standard LDB terminate fitting
  - Weight: TBD lb

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HWCI 2.4.1
Terminate Fitting

- Risk Assessment & Mitigation/Reliability
  - Proven design
  - Risk: Failure to separate
    - Redundant separation pyros and circuits
  - Risk: Premature separation
    - No mitigation
  - Risk: Structural failure
    - No mitigation
- Verification

Req. No.	Requirement	Verification Method
2.4.1.a	Payload Separation	Functional Test
		Test Flight(s)
2.4.1.b	Structural Integrity	Structural Analysis
		Thermal Analysis
		Thermal/Load Test
		Test Flight(s)

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HWCI 2.4.2
Parachute Release

- Requirements Traceability
  - 3.9.2
- Functional and Performance Requirements
  - 2.4.2.a: Provide separation of parachute from payload after land impact
  - 2.4.2.b: Maintain functionality and structural integrity in ULDB environment for mission duration
- HWCI Description
  - Use standard LDB parachute release
  - Weight: TBD lb

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HWCI 2.4.2
Parachute Release

- Risk Assessment & Mitigation/Reliability
  - Proven design
  - Risk: Failure to separate
    - No mitigation
  - Risk: Premature separation
    - Mechanical fail-safe for inadvertent pyro firing
  - Risk: Structural failure
    - No mitigation
- Verification

Req. No.	Requirement	Verification Method
2.4.2.a	Parachute Release	Functional Test
		Test Flight(s)
2.4.2.b	Structural Integrity	Structural Analysis
		Thermal Analysis
		Thermal/Load Test
		Test Flight(s)

HWCI 2.4.3
Cable Ladder

- Requirements Traceability
  - 2.4.1, 2.4.3
- Functional and Performance Requirements
  - 2.4.3.a: Provide structural system between the balloon and the payload that also exhibits torsional resistance
  - 2.4.3.b: Maintain structural integrity in ULDB environment for mission duration
- HWCI Description
  - Use standard LDB cable ladder design
  - Weight: TBD lb
  - Length: TBD ft

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HWCI 2.4.3
Cable Ladder

- Risk Assessment & Mitigation/Reliability
  - Proven design
  - Risk: Structural failure
    - Redundant attachments between payload and balloon
- Verification

Req. No.	Requirement	Verification Method
2.4.3.a	Mechanical Interface	Inspection
		Test Flight(s)
2.4.3.b	Structural Integrity	Structural Analysis
		Thermal Analysis
		Load Test
		Test Flight(s)

HWCI 2.4.4
Truck Plate

- Requirements Traceability
  - None
- Functional and Performance Requirements
  - 2.4.4.a: Provide flight train interface between cable ladder and azimuth pointing system
  - 2.4.4.b: Provide interface between balloon vehicle and launch vehicle
  - 2.4.4.c: Maintain structural integrity in ULDB environment for mission duration
- HWCI Description
  - Use standard LDB truck plate
  - Weight: TBD lb

HWCI 2.4.4
Truck Plate

- Risk Assessment & Mitigation/Reliability
  - Proven design
  - Risk: Structural failure in flight
    - Redundant attachments between payload and flight train
  - Risk: Structural failure on ground
    - No mitigation
- Verification

Req. No.	Requirement	Verification Method
2.4.4.a	Mechanical Interface	Inspection
	(Ladder to Rotator)	Test Flight(s)
2.4.4.b	Mechanical Interface	Inspection
	(Balloon to Launcher)	Test Flight(s)
2.4.4.c	Structural Integrity	Structural Analysis
		Load Test
		Test Flight(s)

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HWCI 2.4.5
Strobe Light

- Requirements Traceability
  - 2.4.4
- Functional and Performance Requirements
  - 2.4.5.a: During ascent, provide visual indicator of balloon location to aircraft below 35,000 ft MSL
  - 2.4.5.b: Maintain functionality throughout appropriate ascent period
- HWCI Description
  - Use standard LDB strobe light
  - Weight: TBD lb

HWCI 2.4.5
Strobe Light

- Risk Assessment & Mitigation/Reliability
  - Proven design
  - Risk: Strobe failure
    - No mitigation
- Verification

Strobe Light		
Req. No.	**Requirement**	**Verification Method**
2.4.5.a	Visual Indication	Functional Test
		Test Flight(s)

HWCI 3.1.4
PV Array Structure & Deployment

- Requirements Traceability
  - None
- Functional and Performance Requirements
  - 3.1.4.a: Provide mounting platform for 212 sq-ft of photovoltaic cells
  - 3.1.4.b: Integrate with payload in stowed position acceptable under launch vehicle restrictions
  - 3.1.4.c: Deploy upon command at float altitude to an fixed tilt angle of 37º from vertical
  - 3.1.4.d: Provide back-up array platforms for powering critical systems
  - 3.1.4.e: Maintain functionality and structural integrity in ULDB environment for mission duration

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HWCI 3.1.4
PV Array Structure & Deployment

- Trade Studies
  - Array Configuration

	Az Pointing Complexity	El Pointing Complexity	Deployment Complexity	Panel Costs	Risk	Schedule	Weight
weight	1	1	1.5	1.5	2	2	1.5
Three-Panel Hinged, Fixed Elevation	7	10	9	9	8	9	10
Single Panel from Gondola Equator, Fixed Elev.	7	10	7	9	6	8	9
Gondola-Mounted Twin Panels, Fixed Elev.	7	10	7	9	6	8	9
Omnidirectional Three-Panel from Gondola Equator	10	10	8	5	7	8	7
Omnidirectional Four-Panel from Gondola Equator	10	10	8	3	6	7	6
Gondola-Mounted Twin Panels, Gimbaled	7	5	7	10	5	5	9
Underslung Single Panel, Fixed Elev.	5	10	5	9	4	5	9
Underslung Vertical Omni Cylinder	10	10	7	1	6	5	1
Underslung Single Panel, Gimbaled	5	5	5	10	2	3	8
Underslung Omni Cone	10	10	4	3	5	4	3
Underslung Three-Panel, Fixed Elev.	10	10	4	5	3	2	5

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HWCI 3.1.4
PV Array Structure & Deployment

- Trade Studies (con'd)
  - Panel Materials

	Weight	Rigidity	PV Cell Interface	Galvanic Corrosion	Risk	Schedule	Cost	Score
weight	1.5	1.5	1	1.5	2	2	1.5	
Aluminum Honeycomb/ Fiberglass Skin Panel	4	4	5	5	5	4	4	**48.5**
Aluminum Channel Frame	5	3	5	5	4	3	4	**44.5**
Aluminum Honeycomb/ Aluminum Skin Panel	3	4	4	5	4	4	3	**42.5**
Aluminum Honeycomb/ Graphite Skin Panel	4	4	4	3	4	4	4	**42.5**

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HWCI 3.1.4
PV Array Structure & Deployment

- HWCI Description
  - Three panels, 73.3 sq-ft each and all tilted 37º from vertical, will be mounted just below the gondola equator
  - Panels will consist of cells bonded to honeycomb sandwich panels
  - The center panel will be fixed; the adjacent panels will be attached to corresponding gondola legs with hinges
  - Deployment will be initiated via pyrotechnic cutters
  - Springs will deploy side panels to final position
  - Side panels will be latched in final position
  - Weight including cells and back-up panels: 80 lb.
  - Power required for deployment: TBD

HWCI 3.1.4
PV Array Structure & Deployment

- Risk Assessment & Mitigation/Reliability
  - New design
  - Risk: Failure to deploy
    - Primary panels still usable for back-up power to critical systems; small (17.7 sq-ft) fourth panel will also supply back-up power
  - Risk: Structural failure upon deployment
    - Small (17.7 sq-ft each) back-up panels under deployable panels will provide back-up power to critical systems
    - Emergency restraint to prevent free-falling items

HWCI 3.1.4
PV Array Structure & Deployment

- Verification

Req. No.	Requirement	Verification Method
3.1.4.a	Cell Mounting Platform	Strength Analysis
		Thermal Analysis
		Vendor QA
		Inspection
		Load Testing
		Subscale Thermal Testing
		Test Flight(s)
3.1.4.b	Vehicle Restrictions	Inspection
		Demonstration
		Test Flight(s)
3.1.4.c	Deployment	Strength Analysis
		Inspection
		Thermal Analysis
		Deployment Test
		Subscale Thermal Vac. Deployment Test
		Test Flight(s)
3.1.4.d	Back-up Panels	Strength Analysis
		Thermal Analysis
		Vendor QA
		Inspection
		Load Testing
		Subscale Thermal Testing
		Test Flight(s)
3.1.4.e	Structural Integrity	Covered by above

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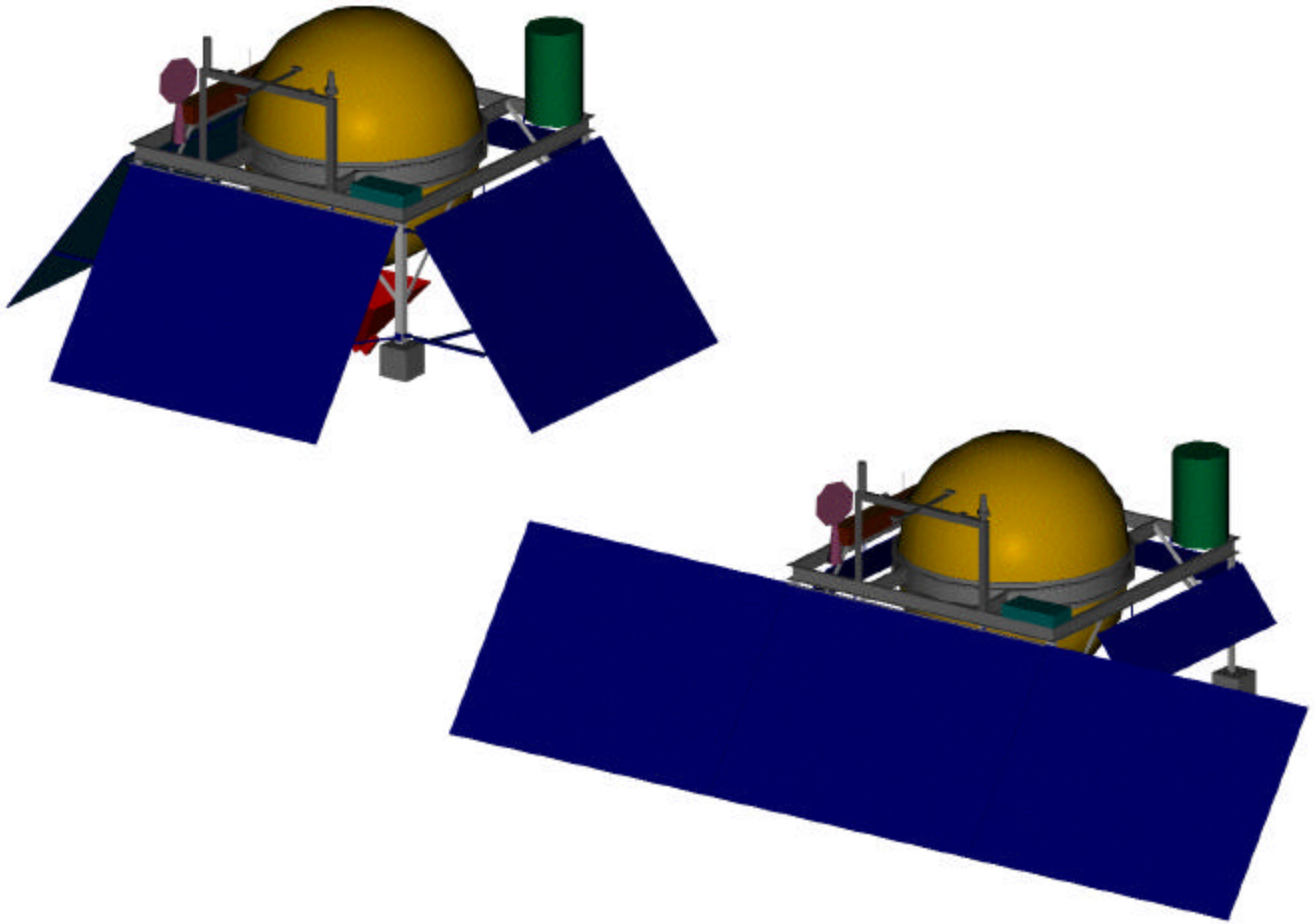
HWCI 3.1.4
PV Array Structure & Deployment



ULDB
PDR

3.1
Power
Systems

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HWCI 3.9.1
TIGER Gondola

- Requirements Traceability
  - 3.9.1
- Functional and Performance Requirements
  - 3.9.1.a: Provide chassis for mechanical integration of TIGER experiment and ULDB support systems, including Command/Data Module, PV arrays and other power components, telemetry antennas, sensors, and cryogenic components as needed
  - 3.9.1.b: Provide interface from gondola to flight train and vehicle systems, including ballast hopper and impact attenuation devices

HWCI 3.9.1
TIGER Gondola

- Functional and Performance Requirements (con'd)
  - 3.9.1.c: Provide adequate protection to systems upon ground impact
  - 3.9.1.d: Maintain structural integrity in ULDB flight environment for mission duration

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HWCI 3.9.1
TIGER Gondola

- HWCI Description
  - Gondola structure will attach to main TIGER structural points, i.e. the two 6-inch aluminum channel cross-members protruding from opposite sides of the sphere equator, with multi-purpose brackets
  - Main platform will consist of C8x4.06 6061-T6 aluminum channels configured in a 10-foot square
  - Substructure consists of 4 each L3x3x3/8 6061-T6 aluminum angle “legs,” reinforced with L2x2x3/8 6061-T6 aluminum angle struts
  - Subsystem components will be mounted on either structural members or platform grating on a case-by-case basis

HWCI 3.9.1
TIGER Gondola

- HWCI Description (con'd)
  - Gondola will interface with the flight train via four 3/8-inch steel cables attached to multi-purpose brackets
  - Ballast hopper will be suspended below the TIGER sphere via four 3/8-inch steel cables attached to multi-purpose brackets
  - Aluminum honeycomb impact attenuation devices (1 cu-ft each) will be attached to the bottom of each gondola leg
  - Weight: 385 lb.

HWCI 3.9.1
TIGER Gondola

- Risk Assessment & Mitigation/Reliability
  - New design
  - Risk: Structural failure
    - Multiple attachment points to flight train and ballast hopper
- Verification

Req. No.	Requirement	Verification Method
3.9.1.a	Experiment & Subsystem Platform	Inspection
3.9.1.b	Flight Train Interface	Inspection
3.9.1.c	Impact Protection	Strength Analysis
		Test Flight(s)
3.9.1.d	Structural Integrity	Strength Analysis
		Load Testing
		Test Flight(s)

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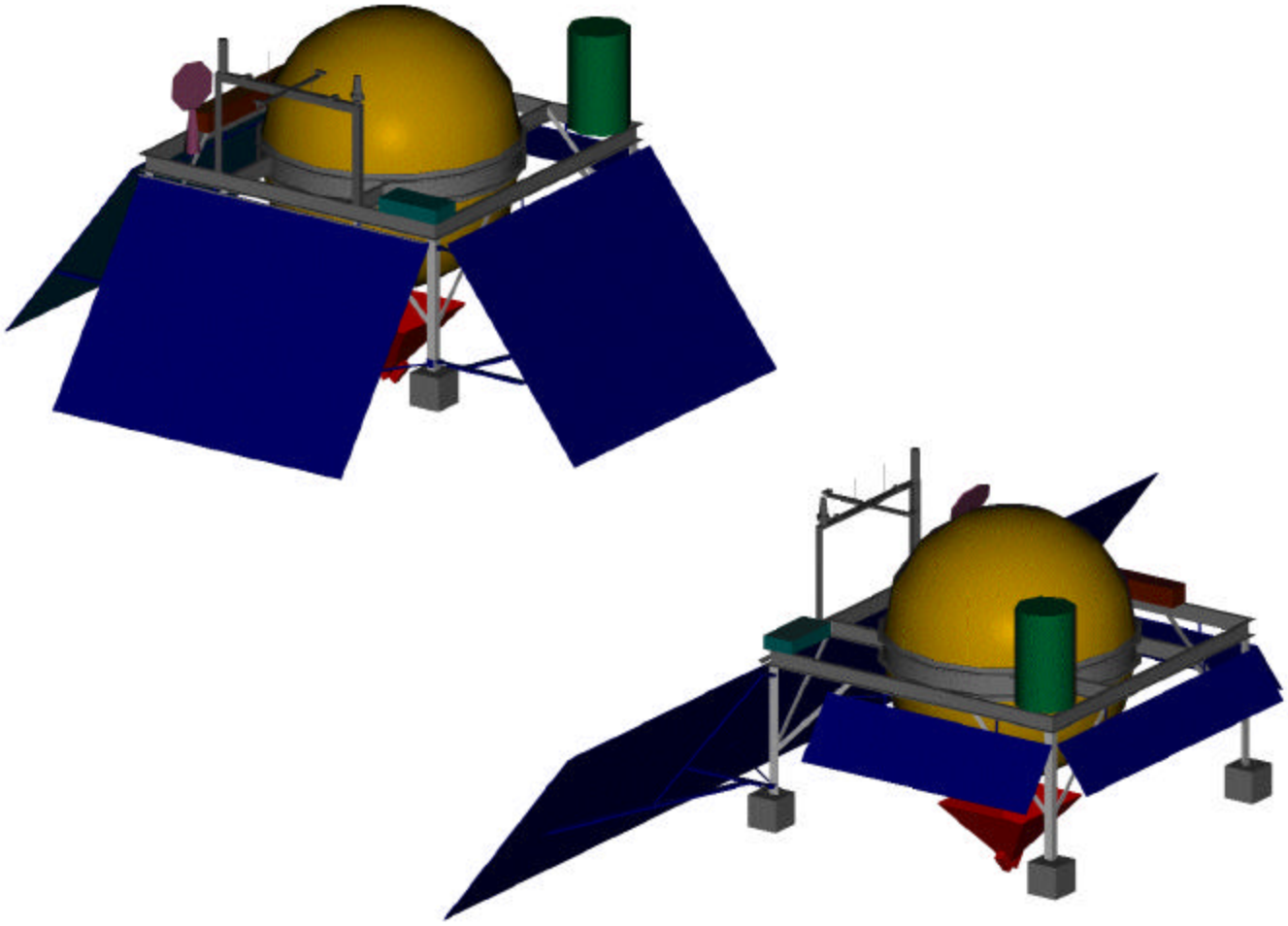
HWCI 3.9.1
TIGER Gondola



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3.9
Mechanical
Systems

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